POPULATION CHARACTERISTICS OF HUMPBACK WHALES IN GLACIER BAY AND ADJACENT WATERS: 1996

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ABSTRACT

Seventy-nine individual humpback whales (*Megaptera novaeangliae*), including seven calves were photographically identified in Glacier Bay and Icy Strait between May 24 and August 31, 1996. Of these whales, 18 were seen solely in Glacier Bay, while 34 were seen only in Icy Strait. Twenty-seven whales were common to both areas. Twenty-one of the Glacier Bay whales and 22 of the Icy Strait whales were resident for more than 20 days. Whales were found in an average water depth of 62 m (*s.d.*=38 , range =13-256) and in an average sea surface temperature of 5.6^{o} C (*s.d.* =1.71, range =3.1-10.1).

INTRODUCTION

The relationship between vessel traffic and humpback whale (*Megaptera novaeangliae)* distribution, abundance and behavior in Glacier Bay National Park has been a concern since the late 1970's when the possibility of vessel-traffic induced habitat abandonment was first raised (Jurasz and Palmer 1981). In the early 1980's, research on whale prey distribution, underwater sound and whale behavior in the presence of vessels attempted to distinguish whether changes in whale distribution were linked to prey distribution and/or vessel presence. Researchers found that whales change their behavior in the presence of vessels (Baker et al. 1982; Baker et al. 1983; Baker and Herman 1989), and that there is substantial spatial and temporal variability in whale prey distribution (Wing and Krieger 1983; Krieger and Wing 1984, 1986). Underwater sound generated by various types of vessels operating at various speeds was also documented (Malme et al. 1982; Miles and Malme 1983). The National Park Service's (NPS) concluded that any of these factors, alone or in combination, could influence whale distribution.

This report summarizes the findings of the NPS whale monitoring in Glacier Bay and Icy Strait during the late spring and summer of 1996, the twelfth consecutive year of consistent data collection on humpback whale population characteristics. The NPS initiated this monitoring program in 1985 to systematically characterize the humpback whale population using the Glacier Bay area, documenting the number of individuals identified, residence times of individuals, spatial and temporal distribution, reproductive parameters and feeding behavior. The whale monitoring program encompasses both Glacier Bay and Icy Strait because whales frequently move between these areas within and between years. Human-whale interactions including strandings, entanglements in fishing gear and vessel disturbance are also documented. When affordable GPS and sophisticated echosounder technology became available, monitoring biologists began to document the precise locations of whales and to describe their habitat characteristics, allowing more contemporary and local descriptions of whale habitat requirements than were previously available (Jurasz et al. 1981, Dolphin 1987). Geographic Information Systems (GIS) maps of whale distribution are already being used to generate information that can be applied to resource management.

The whales that use Glacier Bay and Icy Strait are part of the southeastern Alaska feeding herd, stimated at 404 whales (95% confidence limits 350 to 458) between 1979 and 1992 (Straley 1994). Site delity to the study area is high. Approximately 70% of the whales identified in a given year have been identified in two or more years in the Glacier Bay / Icy Strait region, including 15 whales first identified as calves (Gabriele 1995a). The number of whales using Glacier Bay and Icy Strait from 1985 to 1995 ranged from 41 to 68, with a mean value of 53.9 (*s.d* = 6.9) (Gabriele 1994), with no obvious increasing or decreasing trend. Variability in whale numbers in the study area 1985-1992 does not appear to be attributable to minor variability in monitoring effort (Gabriele et al. 1995a). Whale movement throughout southeastern Alaska is presumed to be linked with prey availability which likely influences the number of whales in the Glacier Bay area (Baker et al. 1990; Straley and Gabriele 1995; Straley 1994).

Whales in the study area typically feed alone or in pairs, primarily on small schooling fishes such as capelin (*Mallotus villosus*), juvenile pollock (*Theragra chalcogramma*), sand lance (*Ammodytes hexapterus*) and herring (*Clupea harengus*) (Wing and Krieger 1983; Krieger and Wing 1984, 1986, Baker 1985, Gabriele 1995b). However, a distinctive 'core' group of 4-12 whales which feeds cooperatively in Icy Strait has been documented since 1981 (Perry et al. 1985). Whales in the study area typically feed below the water's surface, with lunge feeding and bubblenetting observed relatively infrequently (Perry et al. 1985). Whales in the study area appear to have preferred feeding partners (Gabriele et al. 1995b) which do not seem related to kinship or e sex of the individuals.

METHODS

Vessel Surveys: The 1996 humpback whale monitoring program was conducted in Glacier Bay and Icy Strait from late May through August. We observed and photographed humpback whales from a 5 m Boston Whaler powered with a 60 hp outboard engine. The main body of Glacier Bay (a rectangle defined by four corners: Bartlett Cove, Point Carolus, Geikie Inlet and Garforth Island) was surveyed approximately 3 days per week (Fig. 1). Surveys of the upper bay were conducted when whale sightings were reported by other vessels. Upper bay surveys extended as far north as Russell Island in the West Arm and Adams Inlet in the East Arm. Icy Strait surveys were performed once or twice per week, with the greatest survey effort along the shoreline of Chichagof Island from Mud Bay to Burger Point. Several surveys included Lemesurier Island, Gull Cove, the mouth of Idaho Inlet and the north and west shorelines of Pleasant Island. Icy Strait surveys also effectively surveyed the mouth of Glacier Bay in transit from Bartlett Cove to Icy Strait. We generally did not conduct surveys in the same area on consecutive days to minimize the potential impact that monitoring efforts might have on whales. However, if circumstances such as time, weather, or the presence of other vessels prevented whale identification photographs from being taken, consecutive surveys of the same area re made.

After finding humpback whales, we recorded the latitude and longitude position at the start of observation, which was determined with a Magellan NAV1000 Global Positioning System (GPS) using the NAD27 datum. We also recorded other sighting data in field notes, including the number of whales, a general description of whale behavior, water depth, sea surface temperature, environmental conditions, photographs taken and whale identity if known. We monitored and recorded underwater sounds with a hydrophone and DAT deck.

Individual Identification: We took whale fluke photographs with a Nikon 8008 camera equipped with a motor drive, databack, and 300 mm lens. We used high speed (1600 ASA or 400 ASA pushed to 1600) black and white film to obtain clear photographs of the ventral surface of the tail flukes of each whale. Each whale's flukes have a distinct black and white pigment pattern that allows individual identification (Jurasz and Palmer 1981; Katona et al. 1979). Photographs of the dorsal fin supplemented the identification of individuals. Panda Lab in Seattle, Washington processed and printed the film. We analyzed the contact sheets and field notes to determine the dates that each whale was photographed. The season's best photograph of each individual was printed and catalogued.

We compared photographs of individuals to previous NPS photographs and other available catalogs (Jurasz and Palmer 1981; Perry et al. 1985; Perry et al. 1988; von Ziegesar 1992) to determine the identity and past sighting history of each whale. Many whales are referred to by an identification number issued by the Kewalo Basin Marine Mammal Laboratory (KBMML) catalog of North Pacific humpback whales (Perry et al. 1988). Whales first photo-identified by Jurasz and Palmer (1981) are also referred to by their nicknames (Appendix 1). Identification numbers smaller than ID# 950 coincide with those in the KBMML catalog, but those ID#s greater than 950 are unique to Glacier Bay National Park's catalog. In 1996 Glacier Bay National Park began a cooperative project with the University of Alaska Southeast, Sitka, compiling a comprehensive photographic catalog and a computerized sighting database of all humpback whales identified in southeastern Alaska 1981-the present. During this process, we slightly modified the Park's whale numbering system, so that a unified set of identification numbers would encompass all southeastern Alaska humpback whales. As a result, fourteen whale ID#s were changed to avoid duplication with UAS ID#s, and all new whale ID#s issued by Glacier Bay will be greater than 1300.

We assigned temporary identification codes to whales that had not been previously identified in Glacier Bay and Icy Strait, denoting the film roll and frame number of the identification photograph, for example GB96-12(36). Temporary codes were replaced with permanent identification numbers if the whale was identified on more than day, or if it had been identified elsewhere or in previous years. Calves were assigned ID#s if adequate photographs of the flukes were obtained. After photographic analysis was complete, we added the whale's identity and sighting data from the field notes to a computer database containing Glacier Bay and Icy Strait whale sighting histories from 1977 to 1996.

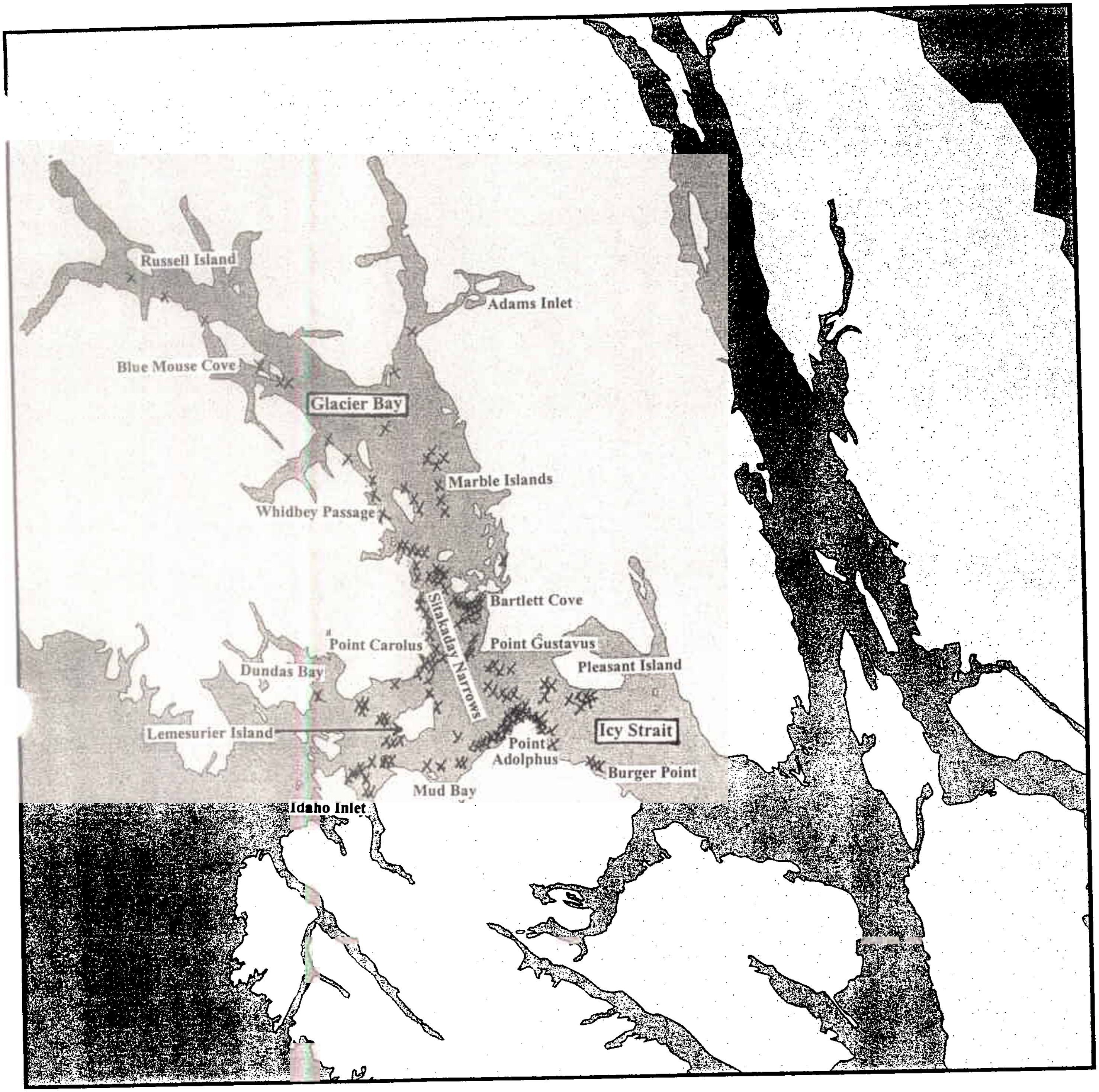


Figure 1.
Humpback Whales in Glacier Bay and Icy Strait 1996

Whale Counts: After all the photographs were analyzed, we counted the number of distinct individual whales in the sample. Separate counts were made of Glacier Bay, Icy Strait, for the total monitoring period and for a 'standardized period' (after Perry et al. 1985) from 9 July to 16 August. The standardized period was chosen by Perry and co-workers to coincide with the study dates in 1982-1984, to allow valid comparisons of counts between years. Although the standardized period is substantially shorter than the current NPS monitoring season, and the beginning and ending dates have no particular biological significance, the standardized counts tend to reflect trends in total counts relatively well (Gabriele et al. 1995a). Continued use of the 'standardized period' is currently the only way of comparing whale counts in 1982-1984 to subsequent years (Gabriele et al. 1995a). We also determined the number of whales that were 'resident' in Glacier Bay, Icy Strait and the study area as a whole. A whale was defined to be resident if it was photographically identified in the study area over a span of 20 or more days (Baker 1986).

We used several statistical methods to determine whether there is any trend in whale numbers in all or part of the study area between 1985-1996, and the effect of survey effort on the number of whales identified. Our general approach was to plot whale count data by year and fit the data with a least-squares regression line, although these data may violate the assumptions of parametric statistics. It is not possible to test for violations the parametric statistical assumptions for these data. For example, testing for violations of the normality assumption would require a distribution of counts for each year, rather than a single point (Zar 1984). Non-parametric statistics do not assume normality, therefore, we also calculated Spearman's rho, a non-parametric correlation coefficient, and used this statistic to assess the strength and statistical significance of the correlation.

Habitat Characteristics and Prey Assessment: We also measured surface temperature and water depth with a Raytheon V850 dual-frequency color video echo-sounder at the start of each pod observation. The temperature sensor was calibrated with a scientific thermometer and was accurate within 0.1 °C. Depth measurements were rounded to the nearest fathom. We qualitatively described the depth, density and morphology of prey patches appearing on the echo-sounder screen in their field notes, and took color slides (200 ASA, shutter speed 1/30) of the echo-sounder screen to capture particularly interesting images. We used standardized gain and chart-speed settings on the echosounder (gain for 50 kHZ and 200 kHz transducers were set at 75%, chart speed was set at 9) to ensure that images observed on different sampling occasions would be comparable. Qualitative descriptions of prey patches were categorized into four types: scattered, linear layers, shapeless masses and ball-shaped. We attempted to determine the type of prey that whales were feeding on by sampling it with a dipnet, minnow traps, a herring jig (a jig is a set of 6 small hooks on a monofilament leader, ployed with a fishing pole), or by visually identifying it. We used field guides (Kessler 1985) to taxonomically identify samples that we collected.

RESULTS

Whale Counts: A total of 79 individual humpback whales were photographically identified in Glacier Bay and Icy Strait between 15 May and 31 August 1996 (Table 3). Of this total count, 27 whales (34 %) were common to both areas. Thirty-four whales, including 1 cow/calf pair, were sighted exclusively in Icy Strait and 18, including 3 cow/calf pairs, were observed exclusively in Glacier Bay. Limiting the count to those whales seen during the standardized period from 9 July to 16 August (Perry et al. 1985), yielded a standardized count of 37 whales in Glacier Bay, 43 in Icy Strait and 64 in Icy Strait and Glacier Bay combined (Table 3). The total and standardized counts of for Glacier Bay, Icy Strait and the entire study area are the highest ever recorded during the monitoring program.

Table 1. Standardized and total counts of humpback whales in Glacier Bay and Icy Strait, 1982-1996

Year	Glacier Bay		Icy Strait		Glacier Bay & Icy Strait	
	Standardized Count	Total Count	Standardized Count	Total Count	Standardized Count	Total Count
1982	22	22	5	15	33	33
1983	10	10	9	9	17	17
1984	24	25	21	22	39	39
1985	10	15	19	30	27	41
1986	26	32	27	35	42	51
1987	28	33	34	48	49	59
1988	17	39	29	36	41	55
1989	20	24	19	30	33	42
1990	16	26	24	34	36	50
1991	16	19	34	40	45	52
1992	27	35	38	51	51	68
1993	23	31	25	33	42	54
1994	17	32	29	42	44	63
1995	18	28	26	45	37	58
1996	37	45	43	61	64	79

Note: Total counts refer to the number of whales (adults and calves) identified during the entire monitoring season. Standardized counts refer to the number of whales sighted between 9 July and 16 August each year. The combined count for Glacier Bay and Icy Strait is typically smaller than the sum of Glacier Bay and Icy Strait counts because some whales are identified in both areas.

We used several methods to determine whether there is any trend in whale numbers in all or part of the study area between 1985-1996 (Fig. 2). Each set of points in Fig. 2 is fitted with a least-squares regression line, and labelled with Spearman's rho correlation coefficient, (see Methods). No significant correlation between whale count and year was found for Glacier Bay or Icy Strait (Fig. 2), indicating the lack of an increasing or decreasing whale number trend in those areas. In the study area as a whole, there was a statistically significant trend of increase at a rate of approximately 3% per year, based on the slope of the regression line (Fig 2a). However, when we re-ran the analysis without the 1996 datapoint to test the possibility that the high 1996 count was placing a strong positive bias on the trend, we found that the statisticially significant trend for the Glacier Bay / Icy Strait study area disappeared (Spearman rho = .506, $p > .10$). Using 1985-1995 data there continued to be no statistically significant trends for Glacier Bay (Spearman rho = .073, $p > .80$) or Icy Strait (Spearman rho = .401, $p > .20$) individually.

As a second avenue of investigating whale number trends, we used the nonparametric Mann-Whitney U to test the hypothesis that whale counts in the second half of the study (1991-1996) were higher on average than those in the first half of the study (1985-1990). No differences in average whale counts were detected in Glacier Bay (χ^2=5, df =5, $p < .4159$), Icy Strait (χ^2=4.4286, df =5, $p < .3511$) or the combined area (χ^2=5, df =5, $p < .4159$), (Fig. 3).

Table 2 shows the number of surveys per month in Glacier Bay and Icy Strait in 1985-1996. Table 3 shows 1985-1996 hours of search and observation time. The May through August 1996 survey effort of 68 surveys and 407 hours total was slightly above the 1985-1995 averages of 54 surveys and 320 hours. A statistical test to determine whether increased effort yielded the increased whale count showed no statistically significant correlations between the number of hours surveyed and the number of whales identified for Glacier Bay (Spearman rho = 0.55, $p<.89$) Icy Strait (Spearman rho = 0.58, $p<.89$) or the study area as a whole (Spearman rho = 0.55, $p<.89$).

We also attempted to determine whether the location, rather than the magnitude, of increased survey effort would account for the increased whale count. Most of the increased survey effort was directed toward western Icy Strait, including the mouth of Idaho Inlet, west Lemesurier Island, and the mouth of Dundas Bay. The pertinent question is whether the whales that use western Icy Strait were identified once or more elsewhere in the study area. Ten of the 12 whales that were identified in western Icy Strait were also identified in eastern Icy Strait and lower Glacier Bay throughout the season. Only two individuals (#1031 and #944) were sighted exclusively in western Icy Strait. Presumably, these two whales would have been missed if we had not surveyed repeatedly in western Icy Strait.

Table 2. Number of humpback whale survey days per month in Glacier Bay and Icy Strait, 1985-1996

Year	Glacier Bay					Icy Strait				
	May	June	July	Aug	Sept	May	June	July	Aug	Sept
1985	0	10	11	10	0	0	7	4	3	1
1986	0	13	17	6	0	0	5	3	6	2
1987	3	12	12	5	1	2	5	7	7	2
1988	0	11	12	12	7	0	5	7	5	3
1989	3	17	14	16	1	1	6	6	7	4
1990	6	16	18	14	0	4	5	6	8	0
1991	7	14	17	13	6	3	7	6	4	3
1992	3	19	17	12	7	2	4	5	4	1
1993	2	10	13	7	1	1	3	3	5	1
1994	1	9	10	13	1	0	5	4	8	1
1995	3	10	11	10	2	2	4	4	7	2
1996	4	11	17	16	3	2	5	10	3	1

Table 3. Total search and encounter time in Glacier Bay (GB) and Icy Strait (IS), 1985-1996

Year	GB (hrs)	IS (hrs)	Total (hrs)	Total Whale Count (GB and IS)
1985	234	92	326	41
1986	-	-	-	51
1987	-	-	-	59
1988	199	108	307	55
1989	231	123	354	42
1990	215	115	330	50
1991	256	100	356	52
1992	248	71	319	68
1993	192	62	254	51
1994	171	92	263	63
1995	181	99	280	58
1996	282	125	407	79

Note: Hours of effort for 1986 and 1987 are not available.

Seasonal Distribution: Whales were observed and identified throughout Glacier Bay and Icy Strait (Fig. 1). Whale distribution was patchy and relatively transitory in most of the study area but there were some consistent areas of high whale abundance, (e.g., Point Adolphus, Bartlett Cove). A distinct peak in whale numbers occurred in July, in contrast to other years when more gradual changes occurred in June, July and August.

Few whales were observed in Glacier Bay in May. Those that were identified were in Sitakaday Narrows and in the upper West Arm. Bartlett Cove, Point Carolus, and Sitakaday Narrows were the areas most used by whales in June, July and August. In contrast to other years, only 4 different whales were observed in Whidbey Passage this season. Twenty-five different whales were identified in lower Glacier Bay in July, during the peak of the season. In upper Glacier Bay, whales were scattered in low numbers over a large area, and it was difficult to predict where they would be found from day to day. However, in late June, two cow/calf pairs and 2 single animals were identified in 2 consecutive days in Blue Mouse Cove. This appears to have been a short-lived event, because there were no previous or subsequent whale sightings reported, particularly by the Park rangers stationed at Blue Mouse Cove. The waters surrounding South Marble Island hosted 3 to 7 whales in June and July. A few whales remained in the lower Bay until mid-September.

In Icy Strait, 10 or more whales were present in the vicinity of Point Adolphus from May through August, with numbers dropping off gradually in September. The peak whale abundance in Icy Strait occurred in July. On July 1 and 2, 28 different whales were identified in Icy Strait. We observed groups of 5 or more whales at Pleasant Island reef in June and July, and single whales were observed there throughout the summer. Also in June and July, Mud Bay and the daymarker between Point Adolphus and Mud Bay hosted 10 or more whales. The mouth of Idaho Inlet also had 4 or more whales present throughout the summer.

Local Movement and Residency: Twenty-seven whales (34% of all identified whales) were sighted in both Icy Strait and Glacier Bay, with 7 individuals (12%), making one or more round trips between areas (Appendix 1). Twenty-one (47%) of the 45 whales that entered Glacier Bay remained 20 or more days, long enough to be considered resident (after Baker et al. 1983). Twenty-two of the (36%) 61 Icy Strait whales were considered resident in that area during the study. Using the same 20 day residency criterion, 47 of 79 (59%) whales were resident in the combined Glacier Bay - Icy Strait area.

Habitat Characteristics and Prey Assessment: We measured sea surface temperature during 126 whale obserservation sessions in 1996. Water depth was measured for 131 sessions. Groups of whales were found in an average water depth of 62 m (*s.d* =38 , range =13-256). The average sea surface temperature at locations where whales were observed was 5.6 °C (*s.d.* =1.7, range =3.1-10.1). Potential humpback whale prey appeared to be distributed throughout the water column, but were primarily in scattered patches (n=18) or linear layers (n=10) or shapeless masses (n=10) of various densities in mid-water. Based on 55 observations of echosounder traces, the average depth of the upper extent of prey patches near whales was 10.97 m (*s.d* = 18.58). The average depth of the lower edge of prey patches was 32.91 m (*s.d* = 20.24). The average vertical extent of prey patches was 22.1 m (*s.d* =15.72). Whales were presumed to be feeding on the potential prey patches that were observed with the echosounder, although it was not possible to confirm this.

We used various methods to determine what type of potential prey was available in the vicinity of whales (Table 4). We made thirteen attempts to use a herring jig to catch small fish that were visible near the sea surface or were detected on the echosounder; only two of these attempts were successful. On June 17 in Icy Strait, we caught 6 herring that we had detected with the echosounder near the seafloor at 60 fathoms. On June 14, we caught 20 cm walleye pollock while attempting to hook some smaller fish that were visible near the surface at Point Adolphus. On July 24, we set 3 minnow traps at various depths on a line with a marker buoy and anchor (trap depths: near surface, 10 fm, near bottom at 20 fm) in Bartlett Cove. The trap near the bottom caught 5 small snails; both of the other traps were empty after a 5 hour soak time. We made visual observations of prey or remains on 14 occasions. The presence of capelin was presumed on 2 occasions, based on the a cucumber odor in the air, which is the characteristic scent of capelin (Kessler 1985).

Table 4. Observations to determine humpback whale prey type

Method	Type of Prey (# of cases)			
	herring	capelin	sand lance	other
Collected fish scales	2			
Collected specimen with dip net			1	
Collected with herring jig	1			1 walleye pollock
'Cucumber' smell in air		2		
Dead fish seen and identified	1	2		
School of fish observed near surface	3	1		1 salmon/dolly varden fry, 3 unknown fish spp.
Seabirds observed carrying away fish				3 unknown fish spp.

Feeding Behavior and Prey Types: We observed 250 different groups of whales. Most whales in Glacier Bay and Icy Strait foraged alone (65%). Other whales were found in pairs (25%), and very few groups (10%) contained 3 or more whales. Coordinated sub-surface feeding by typical members of the 'core group' (Perry et al. 1985) at Point Adolphus was observed in May through early September. The vast majority of whale groups (84%) fed beneath the sea surface, but we observed various styles of lunge feeding (vertical lunges, lateral lunges, lunges associated with the release of bubbles) on 33 (13%) occasions. Flick-feeding 'as observed on 3 occasions, once in Blue Mouse Cove, once near shore west of Point Carolus and once in Vhidbey Passage.

Reproduction and Juvenile Survival: We identified seven cow/calf pairs in the study area in 1996 (Appendix 1). Identification photographs were obtained of 3 of the 7 calves. The crude birth rate (CBR) of the study population, computed by dividing the number of calves by the total number of whales, provides a measure of the reproductive rate for the local population. The CBR for 1996 was 8.9% (Table 5). Whale #1018. who was not previously known to be female, was identified with a calf in upper Glacier Bay this season. Whale #1018 has been sighted in the study area every year since 1989, typically in the West Arm and rarely elsewhere. Several whales that were first identified as calves were re-sighted in 1996, including the first resighting of whale #933, the 1986 calf of whale #566. Whale #933 has been sighted in Frederick Sound in 1988, 1992 and 1995 (J. Straley pers. comm.) Juvenile #1079, the 1993 calf of whale #235 was also sighted again this season.

Whale /Human Interactions: One humpback whale entanglement was reported near the Sisters Islands in Icy Strait on the evening of August 19. The NPS received a telephone call from the National Marine Fisheries Service (NMFS) regarding a humpback whale entangled in netting, 1 mile SW of Sisters Reef, ported by charter vessel M/V *First Addition*. State troopers based in Hoonah went to the location but did not sight the entangled whale. Park biologist Beth Mathews was conducting aerial surveys for harbor seals and did an opportunistic overflight of the Sisters Reef area on August 20 and reported five humpbacks with no sign of entanglement. No further sightings of the entangled whale were reported.

In Glacier Bay, vessel operating restrictions require that vessels remain ¼ mile from humpback whales. However, on several occasions, vessels were reported in close proximity to whales in Sitakaday Narrows, Tidal Inlet and near South Marble Island. Outside the Park, no regulations prohibit vessels from closely approaching whales, although the NMFS marine mammal watching guidelines reccommend a minimum approach distance of 100 yards to reduce the chance of harassing the animals and remain in compliance with the Marine Mammal Protection Act and Endangered Species Act (NMFS 1996). Icy Strait is a popular whale watching location and in recent years has experienced continually increasing whale watching by kayaks, skiffs, charter vessels, tour boats and cruise ships. The potential effects of this traffic on whales in Icy Strait concerns the NPS because many of these whales also use Park waters, and because much of the Icy Strait vessel traffic is related to Park visitation.

Table 5. Crude birth rate of humpback whales in Glacier Bay and Icy Strait, 1982-1996.

Year	#Whales	#Calves	CBR %
1982	33	6	18.2
1983	17	0	0
1984	39	7	17.9
1985	41	2	4.5
1986	51	8	15.7
1987	59	4	6.8
1988	55	8	14.5
1989	42	5	11.9
1990	50	6	12.0
1991	52	4	7.7
1992	68	12	17.6
1993	54	3	5.9
1994	63	9	14.3
1995	58	3	5.2
1996	79	7	8.8

Note: #Whales = total number of Glacier Bay and Icy Strait whales (including adults and calves), #Calves = number of calves, CBR % = crude birth rate, a percentage computed by #Calves / #Whales.

DISCUSSION

Whale Counts: The count of 79 humpback whales identified in the study area in 1996 was the highest since the NPS monitoring program began in 1985 (Table 3), and higher than the 1985-1996 average of 55.8 (s=10.7). We detected no significant difference between the average whale counts in the earlier or later half of the study (Fig. 3), although the power of the statistical test was low due to the small sample sizes and the relatively large variances (Hintze 1993).

We detected a small, statistically significant increase in whale numbers in the Glacier Bay / Icy Strait area as a whole, but found no detectable trend for increasing whale numbers in Glacier Bay or Icy Strait separately (Fig. 2). The Icy Strait whale number trend approached statisticial significance and a significant trend may become detectable with a larger sample size. However, even the increasing trend in Glacier Bay / Icy Strait appears to be strongly influenced by the 1996 count, as the statistical significance disappears when the 1996 datapoint is removed from the analysis. Moreover, the trend in the study area as a whole occurs despite the complete lack of a trend in Glacier Bay, as evidenced by its small correlation coefficient and small slope (Fig. 2) and appears to be much more strongly influenced by Icy Strait whale counts. Additional years of whale counts will be necessary to determine the presence or absence of a robust, lasting trend in all or part of the study area.

The increased effort in 1996 does not appear to account for the higher whale count. Gabriele et al. (1995a) used a bootstrap statistical simulation to investigate the effect of the number of survey days on the number of whales identified and determined that the number of whales identified leveled off after about 60 survey days. Given those results, we would not expect that 68 days of effort would yield such a dramatic increase in the whale count. Additionally, the resighting of most of the western Icy Strait whales throughout the study area suggests that the increased western Icy Strait effort is not fully responsible for the higher whale count.

We emphasize the attempt to detect whale number trends partly because in 1984-1995, NPS used whale numbers, as mandated by the NMFS 1983 Biological Opinion, to determine whether increases in vessel traffic were appropriate. This management strategy was phased out with the implementation of the Park's Vessel Management Plan and Environmental Assessment in 1996. Park management still limits vessel traffic but focuses on reducing impacts to individual whales rather than attempting to detect or manage disturbance at the population level. For example, underwater acoustic monitoring is planned to begin in 1998, which will answer a number of questions that may increase the effectiveness of vessel operating requirements at protecting whales. Whale monitoring provides essential baseline whale population characteristics to enable us to detect human-caused changes.

Distribution: Bartlett Cove had comparatively high levels of whale use, particularly in July, similar to some previous seasons (1992, 1982), continuing to demonstrate that Bartlett Cove is important whale habitat (Fig. 1) as well as an area of high vessel traffic concentration. The north/south distribution of whales in Glacier Bay was typical of previous years, but whales appeared to be less common in Whidbey Passage than in previous years. Icy Strait whale distribution was similar to last year's, with whales distributed throughout the area in June and July, and several whales scattered around Lemesurier Island. In contrast to last year, however, the Point Adolphus area also experienced steady moderate whale use throughout the season.

Feeding Behavior: Most whales foraged alone using sub-surface feeding, as typical of previous observations (Baker 1985, Gabriele 1995b) with a relatively high degree of lunge feeding, as reported in some previous years (Straley 1989, Baker 1986, Baker 1985, Gabriele 1995a). Relatively common lunge feeding may indicate that whale prey was relatively shallow. The "core group" dominated the Point Adolphus area from May through September, in strong contrast to 1995, when the group formed in July and dispersed in September (Gabriele 1995a).

Habitat Characteristics and Prey Assessment: Our results showed that the average potential whale prey pool extended from 11 to 33 m deep, with an average patch height of 22 m. Since 1993, the systematic

Figure 2. Number of whales identified in Glacier Bay and Icy Strait: 1985-1996

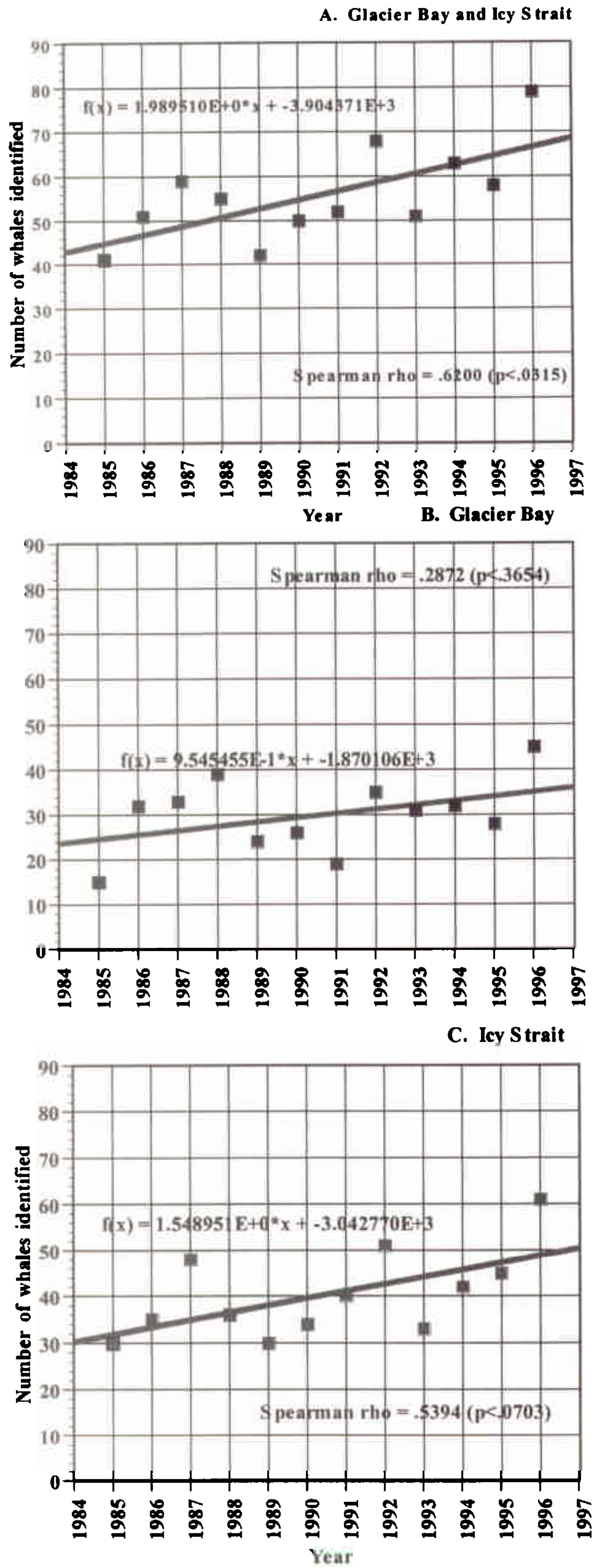
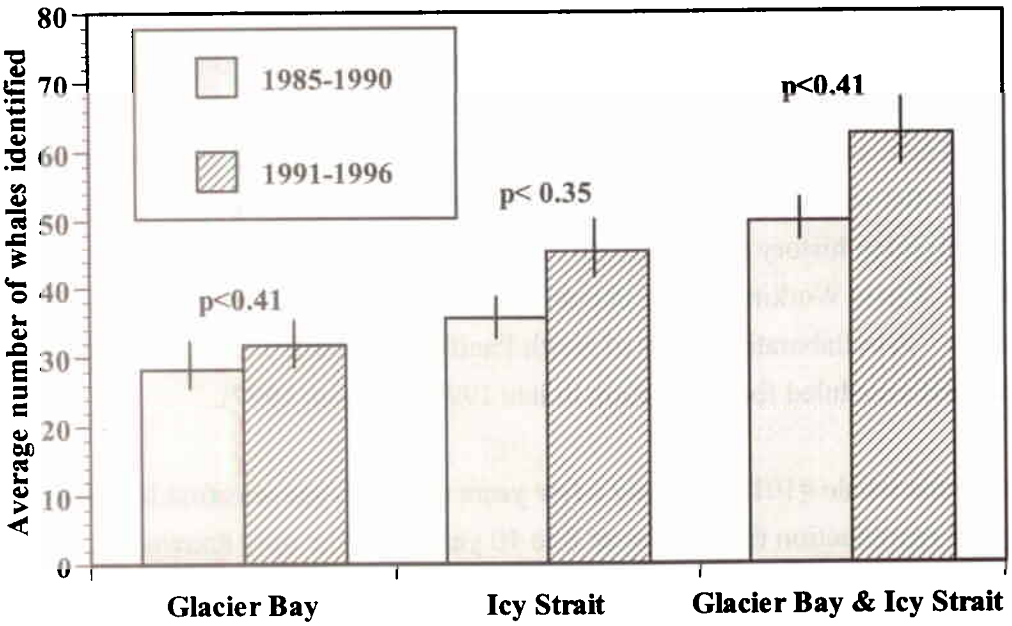


Figure 3. Average number of whales identified in first and second half of study in Glacier Bay, Icy Strait and the entire study area



Note: Bars show average whale counts with standard deviations. No significant differences in whale counts in the first versus the last six years of the study were found in Glacier Bay, Icy Strait or the combined area.

use of the 50/200 kHz depthsounder during whale observations has revealed potential prey at various depths and in a variety of configurations (see also Gabriele 1993, 1994, 1995a). This year's effort to summarize the 1996 data was a fruitful first attempt, from which we learned about the morphologoy and average depths of whale prey patches this season. We hope to summarize the previous years' data for comparison. Our experience with the 1996 data also demonstrated the need for a datasheet and refine and standardize our descriptions of prey patches observed. The resulting dataset will allow qualititative descriptions of humpback whale habitat and prey over the long term.

Fish were visible and identifiable on a number of occasions. Based on these observations and the few fish sampled, capelin appeared to be the main whale prey species in Bartlett Cove, and herring was the main prey item near Point Adolphus and Pleasant Island. These findings are consistent with earlier whale prey work (Wing and Krieger 1982, Krieger and Wing 1984, 1986). Our attempts at sampling whale prey were inefficient and suggest the need for alternative methods. One possibility is the use of an underwater video camera to film and identify fish schools that are within 60 m of the water's surface (L. Haldersen, University of Alaska, pers comm). We will attempt to use this method in the 1997 season.

Reproduction and Juvenile Survival: Whale #1018 has been identified at least once each year for the past 8 years without a calf. It is unlikely that she had a calf prior to the first observation in 1989, because a calving interval greater than 5 years has never been observed in North Pacific humpbacks (Straley 1994, Baker et al. 1987). We surmise that whale #1018 may be a young female who had not previously produced a viable calf. "Viable" is defined here as a calf that survived the migration to the feeding grounds, because a female may give birth to a calf in the wintering area that dies as a newborn or during migration. Whale #1018 does not have a documented sighting history on the Hawaii or Mexico wintering grounds (S. Mizroch, pers. comm North Pacific Humpbakc Whale Working Group unpublished data) and therefore we may never know if the 1996 calf is her firstborn. A collaborative study of North Pacific humpback whale calf mortality during migration is underway and scheduled for completion in late 1997 (Mizroch 1997).

It seems plausible that whale #1018 was only a few years old when she was first identified in 1989, and made her first successful reproduction this year as an 8 to 10 year old. The only known age female in the study area, whale #353, successfully produced her first viable calf at age 8 (Gabriele 1992), although she too may have given birth previously to a calf who did not survive to reach the study area. One other known-age cow was observed with a calf at age 12 in southeastern Alaska (Straley 1994), but this whale has an incomplete sighting history prior to this observation and therefore her age at first birth is not known.

Age at first birth is an important life history parameter in population models, and is critical in assessing population recovery, but has proven difficult to measure in North Pacific humpback whales. These three data points are inconclusive, but suggest that the age at first birth may be higher in southeastern Alaska than the 5 year average age at first birth reported in other populations (Chittleborough 1958, 1959, Robins 1960, Clapham and Mayo 1987, Clapham 1992). A higher average age at first birth in southeastern Alaska humpbacks could presumably alter the lifetime reproductive success of female humpbacks and affect the population recovery rate, thus it is an important topic for future study. More observations of reproduction by known-age females with complete sighting histories will be needed to make a reliable estimate of the average age at first birth for North Pacific humpbacks.

ACKNOWLEDGEMENTS

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Appendix 1. Humpback whale sighting histories

	Whale ID	5/24/96	5/28/96	5/30/96	5/31/96	6/5/96	6/6/96	6/11/96	6/12/96	6/13/96	6/14/96	6/17/96	6/18/96	6/20/96	6/21/96	6/24/96	6/26/96	6/27/96	7/1/96	7/2/96	7/3/96	7/5/96	7/8/96	7/9/96	7/10/96	7/11/96	7/12/96	7/15/96	7/16/96	7/17/96	7/18/96	7/19/96	7/20/96	7/22/96	7/23/96	7/24/96	7/25/96	7/28/96	7/29/96	7/30/96	7/31/96	8/1/96	8/2/96	8/6/96	8/7/96	8/8/96	8/9/96	8/12/96	8/13/96	8/14/96	8/15/96	8/16/96	8/19/96	8/20/96	8/21/96	8/23/96	8/28/96
1	1012					G							G			G							G																																		
2	1014												G	G			G		G	G						G			G						G	G										G											
3	1018																G	G																																					G		
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5	1019							I						I						I																							I				I			I							
6	1031																																				I										I										
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17	117					G							G	G			G				G					G						G			G	G																					
18	118			I			I	G			I								I									I								G					I					G											
19	1213																		I																																						
20	1235																																															I	G		G						
21	1241																							I			I																														
22	1242			I			I													I							I										I																				
23	1244						I																			G						G													G												
24	1246							I						G					G											I																G											
25	1292	G																												I										I																	
26	1293					G																																	G																		
27	1295																																															G		I							

Appendix 1 whale sighting histories

	Whale ID	5/24/96	18/96	4/30/96	5/31/96	6/5/96	6/6/96	6/11/96	6/12/96	6/13/96	6/14/96	6/17/96	6/18/96	6/20/96	6/21/96	6/24/96	6/26/96	6/27/96	7/1/96	7/2/96	7/3/96	7/5/96	7/8/96	7/9/96	7/10/96	7/11/96	7/12/96	5/96	16/96	7/17/96	7/18/96	7/19/96	7/20/96	7/22/96	7/23/96	7/24/96	7/25/96	7/28/96	7/29/96	7/30/96	7/31/96	8/1/96	8/2/96	8/6/96	8/7/96	8/8/96	8/9/96	8/12/96	8/13/96	8/14/96	8/15/96	8/16/96	'9/96	96	8/21/96	8/23/96	8/28/96
28	1303																																																		I										
29	1304							G												I						G																						G									
30	1306											I																				G																									
31	155											I												I				I						I																							
32	157		I	I							I																			I		G				G					I		G				I										
33	159								G			I					G		I								I					G				G			G										G								G
34	160																			I								I	G			G		G		I																					
35	161																G																							G																	
36	166			I			I					I							I					I				I		I				I	G					G							I			I							
37	186						I					I												I				I		I				I													I			I							
38	187																		I																																						
39	196										G						G																											G					G								
40	219			I							I	I												I			I			I											I																
41	1243 calf of 219			I							I	I												I			I			I											I																
42	221																		I				G	G					G			G				G														I							
43	235												G		G	G	G			G	G	G										G			G																						
44	calf of 235												G		G	G	G			G	G	G										G			G																						
45	236							G									G			I		G							G				G							G				G					G			G	G	G		G	
46	237																			G					G						G		G					G																			
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49	351				G												G																G													G									G		
50	352																			I								I		I										I																	
51	353																		I					I						I				I						I							I			I							
52	387																													I																											
53	397																																	I																							
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Appendix 1. Humpback whale sighting histories

	Whale ID	5/24/96	5/28/96	5/30/96	5/31/96	6/5/96	6/6/96	6/11/96	6/12/96	6/13/96	6/14/96	6/17/96	6/18/96	6/20/96	6/21/96	6/24/96	6/26/96	6/27/96	7/1/96	7/2/96	7/3/96	7/5/96	7/8/96	7/9/96	7/10/96
55	516										I	I													
56	539											I								I					
57	559			I																					
58	1245 calf of 559			I																					
59	564																								
60	566							I		G			G				G			I					
61	1247 calf of 566							I		G			G				G			I					
62	573			I			I					I							I					I	
27	577																			I					
64	581											I												I	
65	584													I											
66	587			I				G				I							I					I	
67	801																G	G							
68	calf of 801																G	G							
69	817																		I						
70	?/9																		I						
71	933																								
72	937	G		I			I	G									G		G			G			
73	941																			I					
74	944													I						I					
75	G96-45(24)																								
76	G96-46(36)																								
77	G96-57(15)																								
78	G96-58(32)																								
79	G96-79(12A)																								

	Whale ID	7/11/96	7/12/96	7/15/96	7/16/96	7/17/96	7/18/96	7/19/96	7/20/96	7/22/96	7/23/96	7/24/96	7/25/96	7/28/96	7/29/96	7/30/96	7/31/96	8/1/96	8/2/96	8/6/96	8/7/96	8/8/96	8/9/96	8/12/96	8/13/96	8/14/96	8/15/96	8/16/96	8/19/96	8/20/96	8/21/96	8/23/96	8/28/96
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57	559																																
58	1245 calf of 559																																
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62	573			I		I				I						I							I			I							
27	577															G							I										
64	581			I		I				I																							
65	584					I							I						I			G											
66	587			I		I				I													I			I							
67	801																																
68	calf of 801																																
69	817																																
70	?/9																																
71	933	G										G																					
72	937				G			G		G		G				G					G	G		G				G					
73	941			I		I																				I							
74	944																																
75	G96-45(24)			I																													
76	G96-46(36)			I																													
77	G96-57(15)								G																								
78	G96-58(32)									I																							
79	G96-79(12A)																						I										